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CULTIVATION OF NEGLECTED TROPICAL FRUITS WITH PROMISE

Part 2. The Mamey Sapote

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NOTICE TO READERS

Most countries regulate the use of pesticides and establish the amount of pesticide residues permitted on raw agricultural commodities. In the United States, the Federal Insecticide, Fungicide, and Rodenticide Act, as amended, governs the use of pesticides; and the Food, Drug, and Cosmetic Act, as amended, governs pesticide residues. The Environmental Protection Agency (EPA) administers the former Act and the pesticide-residue provisions of the latter Act. At this writing, the pesticides mentioned in this publication are not registered by EPA for use on the mamey sapote nor have residue tolerances been established. Individuals interested in cultivating the fruit commercially or in exporting it should check the pesticide regulations of the importing country.

CULTIVATION OF NEGLECTED TROPICAL FRUITS WITH PROMISE

Part 2. The Mamey Sapote

By Narciso Almeyda and Franklin W. Martin[1]

ABSTRACT

One of the best fruits of the Western Hemisphere, and yet one that is relatively unknown, is the mamey sapote, *Calocarpum sapota* (Jacq.) Merr. Widely distributed in Central America before Columbus, the encroachment of civilization has actually reduced the availability of this fruit. Those who know it well believe that there is no better fruit. Its creamy texture and rich flavor are unmatched. The mamey sapote is a large-spreading tree commonly propagated from seeds, but this method leads to trees of variable quality. Selected trees can be propagated by the tedious method of inarching. Other propagation techniques have not given satisfactory results. Trees are grown in a wide variety of soils, chiefly in regions of heavy rainfall (the humid Tropics). Trees can be established first in containers and then transplanted at the beginning of the rainy season. Regular fertilization, weeding, and supplemental irrigation are desirable. Cover crops are useful, especially during the period of establishment of the orchard. Pruning is done to shape the tree and remove dead wood. A few insect and disease problems occur, but these can be avoided or treated. Fruits are first borne in grafted trees at 3 years of age, and on seedlings at 7 years. When the fruit begins to redden, it is ready for harvest, which should be done carefully to avoid damage and maintain fruit quality. After harvest the fruit ripens in a few days. **KEYWORDS: fruit, fruit cultivation, mamey sapote, mamey sapote cultivation, tropical fruit, tropical fruit cultivation.**

INTRODUCTION

A number of exotic fruits can be found in the Western Hemisphere that are practically unknown even though they were introduced from the Far East many years ago. Some of these fruits are delicious and are important crops in their countries of origin. In this hemisphere, they are represented only by a few specimens in botanical gardens and private collections. Among these are the mangosteen, *Garcinia mangostana* L., considered by some to be the most delicious fruit of the world, the langsat, *Lansium domesticum* Jac., one of the most appreciated fruits of the Philippine Islands, the durian, *Durio zibethinus* Murr., which on the island of Borneo is considered the king of the fruits, the litchi, *Litchi chinensis* Sonn., a fruit of subtropical China, and others.

The reasons for this neglect of these special fruits are many, including the apathy of many people towards a new fruit or vegetable, the erroneous belief that these trees need much time to come to fruit, a lack of knowledge of good propagation techniques, and the lack of information concerning their cultivation. Ironically, the same

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neglect occurs with respect to some fruits of the Western Hemisphere: delicious fruits of high nutritional value are ignored by the majority of the public. One of these fruits is the mamey sapote (pronounced mah-may sah-poh-dee), *Calocarpum sapota* (Jacq.) Merr., one of the finest fruits of the Americas.

Before the discovery of America by Columbus, the mamey sapote was one of the most important and most coveted foods of Central America and was produced in great numbers. According to accounts, this fruit was at times the only food available to the soldiers of Hernando Cortés, during his march from Mexico City to Honduras in 1524 *(18)*.[2]

In many countries of South America, the esteem in which the mamey sapote is held is shown by the habit of leaving these trees undisturbed when deforesting a new piece of land. The old trees found in the forest today are often signs of places that were previously inhabited. Now, with impetus from new crops and with new techniques for planting, this practice of conserving these trees is disappearing, and in some areas the fruit is difficult to obtain.

Few countries have had the foresight to preserve this important resource, but the Cubans feel that no other fruit can be compared with the mamey sapote. There is currently a great demand for this fruit in the continental United States and in other places where Cubans have settled.

The purpose of this bulletin is to call attention to the cultivation of this delicious fruit. Considering the appreciation that the Cubans have for this species and its high nutritive value, the mamey sapote should be planted not only in the home garden but also on a commercial scale.

THE MAMEY SAPOTE

Origin

There seems little doubt that the mamey sapote originated in the lowlands of Central America, where it often grows wild from sea level to an altitude of 1 km *(11, 18)*. From there it has been introduced to the countries of the Caribbean, South America, Hawaii, and the Philippine Islands *(2)*. In the Caribbean, it is found in almost all countries, especially in Cuba and the Dominican Republic. The Spanish are believed to have played an active role in its distribution. In 1939, seeds of a particularly good selection were introduced to the Mayagüez Institute of Tropical Agriculture (MITA), Mayagüez, P.R.

Introductions to Florida, first made many years ago, had not progressed much, possibly because of problems with the soil, but also because of a lack of interest. Since the influx of Cubans, commercial plantings have been established.

The name "mamey" originated from a confusion with the tree mamey, *Mammea americana* L. The exteriors of the fruits of the two species are somewhat similar, and the internal colors are about the same. In Puerto Rico, the word "mamey" also means orange. Almost everywhere the mamey sapote has been known, the name "zapote" is used, a word of Aztec origin (tzapotl), meaning fruit. It is known as zapote in Venezuela, Ecuador, Colombia, Central America, and Mexico. In Trinidad, Barbados, Dominica, and Jamaica, it is known as mamee sapota, marmalade plum, or marmalade fruit. In Guadaloupe and Martinique, it is called sapote or grosse sapote. In Cuba, the names "mamey colorado" and "mamey sapote" are used. In the Philippines and the Malay Peninsular, it is known as chico zapote or chico mamey. In Florida and California, the name "marmalade plum" is given. In Puerto Rico, the fruit is always called mamey zapote.

FIGURE 1.—Mamey sapote trees in production at the Mayagüez Institute of Tropical Agriculture. These trees were established from a good selection of seeds from Guatemala in 1939.

[2]Italic numbers in parentheses refer to items in "Literature Cited" at the end of this publication.

Botanical Description

The mamey sapote belongs to the family Sapotaceae, which includes other fruits such as the sapodilla, *Achras zapota* L., the green sapote, *Calocarpum viride* Pittier, the cainito or star apple, *Chrysophyllum cainito* L., and the canistel, *Pouteria campechiana* Bachni. The tree is large, reaching 30 m in height, with a wide trunk, large branches, and abundant foliage (fig. 1). The leaves are entirely obovate or oblanceolate, wider near the extreme tip than near the petiole, 14 to 30 cm in length, shiny dark green on the upper side and lighter below. Each year new branches are formed, consisting of 8 to 10 leaves arranged compactly (fig. 2). Below these new branches and along the length of leafless branches the flowers appear in large quantities. The flowers are small and almost sessile (fig. 3). The calix consists of 8 to 10 overlapping sepals, and the corolla is a tube of five white petals. There are five fertile stamens and five staminoids. The pistil is cone shaped and pubescent and terminates in a simple stigma. The ovary consists of five carpels with an ovule in each cell *(1, 13)*.

The fruit is ellipsoidal or ovoidal, with a prominent permanent calyx at the base, and a remnant of the pistil at the apex (fig. 4). It measures from 10 to 25 cm in length by 8 to 12 cm in width and many reach a weight of 3 kg. The thin but strong cortex is roughened and colored a rusty brown. The pulp is salmon colored, thick, aromatic and sweet, soft when ripe, almost free from fiber, and can be eaten with a spoon. Normally the fruit contains only a single seed, ellipsoidal or spindle shaped, 5 to 6 cm in length, with a hard testa. The color is that of coffee, and it is shiny except for a segment colored tan.

The mamey sapote is usually eaten fresh. The fruit is cut into two with a longitudinal cut, and the seed is easily removed. The smooth pulp can be eaten directly from the fruit. The cortex is hard and thus resists deformation during eating.

FIGURE 2.—Branch and fruit of the mamey sapote. Observe the formation of annual branches and the location of the fruit on the branches.

FIGURE 3.—The abundant, small, sessile flowers of the mamey sapote. Observe the groups of 8 to 10 leaves at the apex of the branches.

FIGURE 4.—The fruit of the mamey sapote with its thin rough cortex colored brown. The pulp is a reddish-brown.

In some places of the Caribbean, delicious drinks of salmon-red are prepared from the mamey sapote *(3)*. The fruit is also used in the preparation of jellies and pastes, known as cream of mamey, and it has been used as filler in the preparation of guava paste *(20)*.

For every 100 g of edible portion of the mamey sapote, there are 67.5 g of water, 26.98 g of carbohydrate, 1.41 g of protein, 0.74 g of fiber, and 1.32 g of ash. The mineral content per 100 g of edible portion is: calcium, 46.7 mg; phosphorus, 22.9 mg; niacin, 1.574 mg; and ascorbic acid, 18.4 mg.

The seed of the mamey sapote, called zapoyola in Mexico and Central America, is milled to prepare a somewhat bitter chocolate *(7, 14)*. The wood of the tree is reddish and solid, and it is used in the construction of carts and furniture, or whenever an especially strong wood is needed *(8)*.

Varieties

Little has been written concerning the varieties of the mamey sapote *(15, 19)*. Because the species is propagated by seed, and is apparently cross-pollinated, a great variety of forms and sizes of fruit have been seen, as well as variations in the color of the pulp. The form of the fruit varies from almost spherical to long and football shaped. The weight can reach 3 kg, but there are other varieties with fruits as small as 250 g. The pulp varies from an orange-yellow to a dark red, but the exterior color of the cortex is the same.

A large number of mamey sapote trees of seedling origin produce high-quality fruit. These would merit vegetative propagation to gain uniformity in production and quality. In Florida, at least four selections are now propagated vegetatively and are recognized as excellent varieties *(5, 12)*. In El Salvador, the variety 'Magana' is characterized by large fruits, up to 1.5 kg. The pulp is of high quality, and the fruit matures in less than 1 year. This variety was introduced to Florida in 1962 and is now commercially cultivated. However, the yield per tree has not been great. Another variety, known as 'Cuban No. 1', was introduced from El Salvador but presumably originated in Cuba. It also is large fruited. The fruits reach 22.8 cm in length and a kg in weight.

On the coffee farms in the western part of Puerto Rico, a number of prolific trees bear large fruits, sometimes of 1 kg or more, with dark red flesh. It would appear profitable to propagate vegetatively at least the best of these.

CULTIVATION

Propagation

Seeds

The lack of knowledge about vegetative propagation of the mamey sapote has limited the culture of this important fruit. Little scientific study has been made to determine the best methods of propagation, leading to a loss of interest in the growing of this species *(5, 10, 15)*. Interested farmers have had to establish new trees from seed, even though this method of propagation is the least desirable. Seedlings take much more time to come into production than trees propagated vegetatively, a fact that has contributed to the myth that this species needs an exceptionally long period before it begins to bear.

When the mamey sapote is propagated from seed, the seedlings may not resemble the parent in size, form, or quality of the fruit. Nevertheless, this method will probably continue to be the principal form of propagation.

Seeding may be done in seed flats, in polyethylene bags, in tin cans, or in the soil where the tree is expected to grow. The seed flat should be at least 10 cm deep, so that roots will have room to grow. The medium for planting can consist of two parts loam, one part organic material, and one part soil. The same mixture is also used for transplanting to polyethylene bags. Seeds should be planted in lines 5 cm apart, with the shiny surface upright and slightly exposed.

Some growers prefer to plant in moss, for it makes transplanting much easier. In addition, less damage is done to the roots when transplanting from moss, and the percentage of survival is much higher. Sometimes a mixture of 60 percent moss and 40 percent perlite is used as a planting medium.

The largest seeds available should be selected, because they generally produce larger and more vigorous seedlings. Size and hardiness are important, especially when the trees are to be grafted. The seeds need about 30 days to germinate. When the trees reach 10 to 15 cm, they should be transplanted to polyethylene bags or directly to the field (fig. 5). Small weak plants should be eliminated, for these grow too slowly. Either 4- or 11-l bags can be used. The 11-l bags, while giving much more room for the growing tree, are harder to handle in the field. In the large bags, the trees can reach about 75 cm before it is nec-

essary to transplant them. Larger plants in the field mean more resistance to weather and other inclement factors. The direct transplanting from seed flat to field is the most economical technique, but also the most risky.

Asexual methods

In general, the asexual propagation of Sapotaceae trees has been difficult. Some success has been had with members of the family other than the mamey sapote. The sapodilla, for example, has been successfully propagated by means of the side-veneer graft and the cleft graft. But these methods have been only occasionally successful with the mamey sapote *(17)*. Research is needed to perfect these methods and to develop others.

Cuttings.—The use of cuttings has been the best known method of asexual propagation for centuries, for it is the easiest method to use. Generally, cuttings are made from the center of the branch, where the wood is neither too tender nor too mature, and placed to root without further treatment. However, there are other kinds of cuttings, methods of preparation, and ways of planting them.

Cuttings afford a number of advantages. The resulting plant is genetically identical to the mother plant, the cost of propagation is usually low, the technique is simple and can be easily taught to anyone, and there are no problems of incompatibility, as in the case of grafting techniques. The great problem in the case of many species is that it is difficult to stimulate root production.

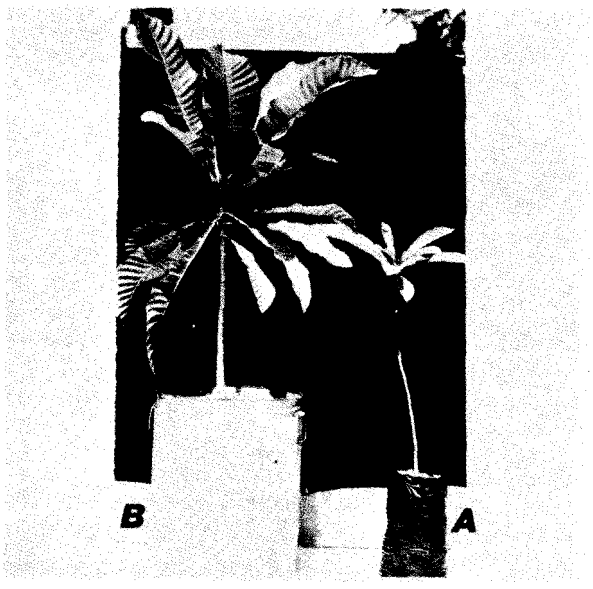

FIGURE 5.—Two different containers used in transplanting small trees. *A*, Polyethylene bags, 1-gallon size; *B*, 5-gallon can.

Studies have been made at MITA on the possibility of propagating the mamey sapote from stem cuttings. In these studies, terminal mature branches of recent new growth were used. The cuttings, 15 to 20 cm in length, were divided into two groups, in one of which the leaves were cut in two pieces to reduce leaf area and transpiration rate. Half of each group was treated with a powder containing indolebutyric acid, a hormone often used to stimulate root growth. The treatment consisted in covering the extreme portion of the cutting with the powder and shaking off the excess.

The cuttings were planted in a medium of fine river gravel and were subjected to a fine mist spray 3 seconds of each minute during the day. These treatments have stimulated germination of roots in other plants.

Although a callus was sometimes formed, roots were not produced by any of the treatments. Thus, there is a suggestion of a favorable response to the treatments, but the stimulation necessary to produce roots appears to have been inadequate. Future trials should be more extensive and should include all of the variables that might affect rooting of cuttings.

Grafting.—The technique of budding or bud grafting is one of the most widely used grafting techniques. Known also as the T-graft, it consists of grafting an axillary bud removed from the desired parental tree below the cortex of a young seedling scion. The bud is inserted in an incision made in the form of a T, although some persons prefer an inverted T. Many details of the procedure are varied according to the grafter, in the manner of cutting the incision, the budwood, and so forth *(17)*. The vertical cut is usually made first and should be deep. The horizontal cut, covering up to one-third of the circumference of the young trunk, ought to penetrate to the wood itself. The borders of the cut should open or opened slightly to facilitate the entrance of the bud.

The bud patch is obtained by means of an oblique cut into the stem that begins about 1.3 to 1.5 cm above the bud, penetrates slightly the wood below the bud, and continues about the same distance below the bud. A horizontal cut is made about 2.5 cm below the point of entrance to sep-

arate the bud from the stem. The bud is then inserted in the T in such a manner that it forces open the cortex and is caught between the cortex and the stem. The cut, except for the bud, is covered with a rubber strip designed for this purpose by winding the strip in an upward spiral. The entire area is covered with a paraffin strip wound in the same manner, giving protection against moisture loss.

Certain details are especially important in a successful patch graft. The stock should be of the appropriate species or variety and in a state of vigorous growth. The buds of the scion must be selected carefully. The equipment for grafting should be perfectly clean and in good condition. The incision should be perfectly clean, and the knife should be well sharpened. Among the items of equipment that should be on hand are the sharpened grafting knife, a pruning saw, a sharpening stone, grafting rubber, strips of paraffin film, and alcohol or another mild disinfectant.

Patch budding the mamey sapote has not been completely satisfactory, probably because of the great amount of latex exuded on cutting the cortex. The Forkert technique has been recommended. Pennock has successfully used this modification with the sapodilla (*17*).

The Forkert method consists in removing a bud centered in a rectangular patch of cortex with some attached wood. This patch is inserted between the wood and the cortex of the stock by making two parallel vertical cuts at the sides of the bud, about 1 cm apart, entering the wood to a depth of about 2 mm. Two horizontal cuts about 4 cm long are then made to release the bud and attached wood. The wood is then removed from the patch, and matching parallel cuts about 6 cm in length are made on the stock. After a transverse cut, the cortex is lifted carefully, and the bud is inserted so intimate contact is made with the stock. The patch is covered with the tongue of cortex, except for the bud itself, and is tied in place with rubber and protected with paraffin film.

The method preferred in Florida for the propagation of the mamey sapote is the side-veneer graft (*4, 16*) (fig. 6). Only vigorous growing materials of approximately the same diameter should be used for this purpose. This graft consists of removing a slice of the stem of both the stock and scion. The stock cut is made somewhat above the crown, about 2 inches in length, and should include part of the wood. This cut is terminated with a horizontal cut inward leaving a small "stair." The scion, preferably a terminal branch that has just begun to expand with new growth, is cut in a complementary form to match the cut of the stock. The two are carefully fitted together so that the cambial zones are touching, tied with a strip of rubber, and covered with a strip of paraffin film.

This approach graft has been recommended for the mamey sapote because the technique is usually successful (*15*). In this method, the scion and the stock remain united with their own roots, especially at the beginning. It is somewhat laborious, however, and requires special attention. One of the plants, usually the stock, is planted in a pot. If the graft is made with a mature tree, it is necessary to suspend the potted plant from the tree, or to support it on one way or another at the place where the graft is accomplished. The grafting consists of removing equal sections from the sides of the stems of the stock and the scion. Normally, branches of similar size are used for this technique. The cut is made almost to the center of the stems. The two branches are then bound together so that the cambiums match, and the graft is covered with rubber and paraffin strips. When the graft union is strong, the connection with the mother tree is gradually eliminated.

Air layering.—The air layer (marcot) is an old method of propagating plants vegetatively, con-

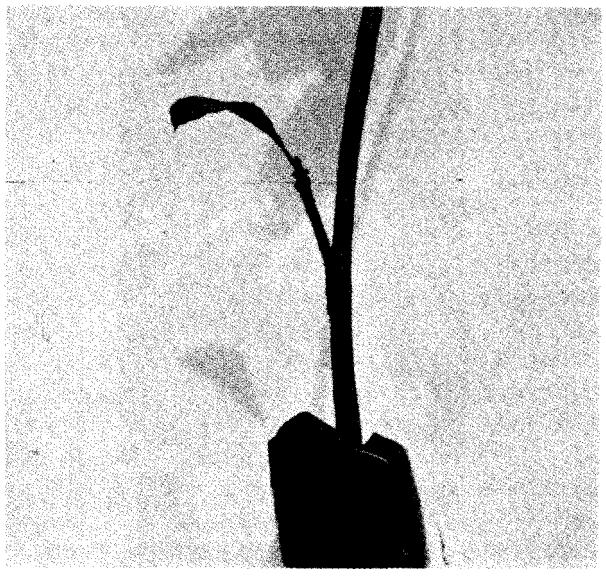

FIGURE 6.—Propagation of the mamey sapote by means of a side-veneer graft, the most common method for propagating this species.

sisting essentially of stimulating root formation of a branch that has been ringed and continues as part of the mother plant (fig. 7). The first step in air layering is to select healthy branches 2 to 2.5 cm in diameter. The leaves and small branches are eliminated near the site where rooting is desired. One cut is made around the branch and another at a distance of 2.5 cm, and a ring of cortex is removed. The stem is scraped if necessary to remove any remnants of the cortex. A rooting agent is applied to this area. Any of a number have been used, but indolebutyric acid is especially effective *(15)*.

The ringed area is covered with damp moss, which in turn is covered with a black polyethylene sheet. Maintenance of the moss in a humid state is one of the big problems in propagating by marcots. Polyethylene is permeable with respect to gases but retains water vapor. It resists weather conditions but disintegrates with time.

Tests have been made at MITA to investigate the possible use of air layering as a propagating technique with the mamey sapote. Air layers were prepared at approximately 6-week intervals for 1 year, beginning in March 1967 and ending in December 1968. As a rooting agent, indolebutyric acid was used. The sphagnum moss was sterilized before application. Two months after tests were begun, the air layers were cut from the tree and examined for root production. In only 2 of the 20 air layers were roots produced. Although these particular air layers died after transplanting, there is promise for this technique, if more thorough investigation can be made of the problem.

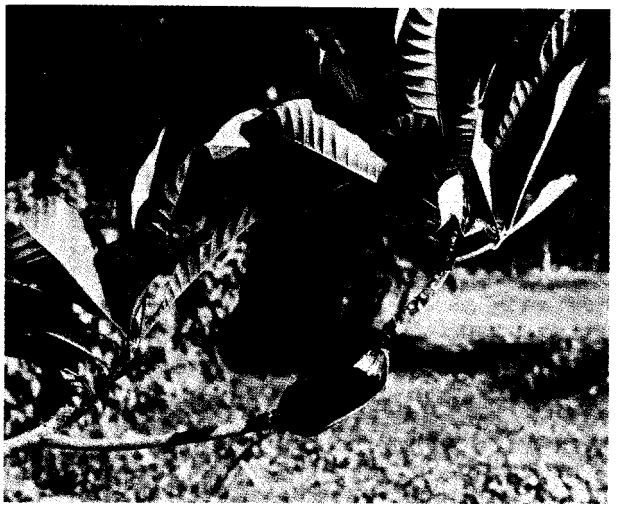

FIGURE 7.—Vegetative propagation by means of the air-layering technique.

Soils

The mamey sapote is tolerant of many soil types. It prospers in the heavy clays of Puerto Rico, in the sandy clays of Guatemala, and in the limestones and sands of Florida *(4, 9)*. In its areas of origin, wild mamey sapote is found in untouched or abandoned areas where a certain amount of natural fertility might occur through the accumulation of organic material.

In Puerto Rico, the mamey sapote is encountered in a great number of soils (fig. 8). At Mayagüez, several healthy and productive trees are found in soils of the series Humata and Daguey. Such soils are clayey, acidic, with only moderate permeability and fertility, with organic material, and subject to rainfall ranging from 1,700 to 2,300 mm per year. In times of drought these soils sometimes present serious cracking problems, subsequently damaging the roots of plants. Deep cracks also cause problems during irrigation because they lead to heavy losses of water. This soil condition reduces the growth potential of any plant not resistant to it.

In Puerto Rico, several well-developed and productive trees are found in Barrio Anones, Las Marías, where the soils are deep, acidic, with moderate permeability but good drainage. Fruits here are especially large and of good quality. The climate in this area is humid, and the rainfall is similar to that at MITA.

FIGURE 8.—Mamey sapote trees planted in a clay soil of moderate permeability, moderate fertility, and high acidity.

Trees have also been observed in soils of the series Machete near the town of Arroyo, in the southeastern part of the island. These soils are acidic, fine textured, moderately permeable, and well drained. The rainfall is only 750 to 1,200 mm per year. This type is much like the soil in which the mamey sapote is grown in Florida.

In contrast to the above soils, the mamey sapote grows satisfactorily in soil of the series Guerrero, in Isabela. This soil consists of deep, porous sands of poor fertility, in an area of low to moderate rainfall (500 to 1,000 mm per year).

Experience in Puerto Rico shows that the mamey sapote may be grown in a wide variety of soils. The soil characteristics essential for cultivation of the mamey sapote appear to be good depth and drainage, acidic reaction, and moderate permeability and fertility. Many such soils are present in Puerto Rico, as well as in other parts of the Tropics, and we believe that the mamey sapote would grow well in other areas and soil types not yet tested.

On the other hand, the mamey sapote will not tolerate poor drainage or a water table that is too high. Such conditions reduce the exchange of gases so necessary to growth, severely damaging the tree. Other undesirable conditions are a rocky subsoil and a subsoil of impermeable clay, both of which restrict root growth, making the tree unable to resist either drought or strong winds.

Planting

The planting site should be free of large trees, bushes, old trunks, weeds and other obstacles. The soil should be prepared by plowing and disking. If plantings of another crop are not to be made among the trees, it will be necessary to clean only those sites where the trees themselves are to be planted. Such planting sites should be at least 2 m in diameter.

In areas that are flat or only slightly inclined, the trees can best be planted in lines at equally spaced intervals to form rectangles. This pattern facilitates the passage of machinery for cultivation, pest control, and harvest.

The planting distance should be selected carefully, for it affects the production and quality of the fruit. If the distance is correct, the tree should have sufficient space and full access to sunlight. Trees too closely spaced invite disease and insect attack. Planting distance varies with soil fertility, variety, and full size of the mature tree. In fertile soils, a planting distance of 8 by 8 m is recommended. In less fertile soils, distances can be reduced to 7 by 7 or 6 by 6 m. Varieties that produce large fruits should always be planted at spacings of 8 by 8 m. Trees from seed grow larger and need more space than trees propagated vegetatively.

If possible, the holes for planting should be made days in advance to permit the soil to aerate. The hole should be large enough to accommodate the plant easily and to permit the addition of a good quantity of loose soil into which the roots can rapidly grow. A planting hole 0.75 m in diameter and 0.75 m deep is recommended. When the hole is dug, the topsoil should be maintained separately from the subsoil. At planting, some of the topsoil should be placed in the bottom of the hole to provide nutrients and permit easy root penetration. Well rotted organic material mixed with soil will aid in the establishment of the tree.

The best time for planting is the beginning of the rainy season, especially if irrigation is not possible. At planting, the container will have to be removed, for the plastic bags or tin cans will not rot in the soil. Although roots may pass through holes in the containers, the normal development of the root system is impeded by the container.

The tree should be planted at the same level in the soil as it was in the container. The soil should be carefully placed around the roots to eliminate pockets of air. The soil should be packed carefully to avoid injuring the delicate roots. It is recommended, especially in zones of low rainfall, to make a small depression around each trunk to facilitate the penetration of water. If wind is a problem, temporary windbreaks of burlap bags, palm leaves, or any other cheap material can be used. It is useful to place a mulch below each plant to conserve moisture and to prevent the growth of weeds.

Fertilization

The use of fertilizers is necessary from the beginning. In the case of young trees in containers, a foliar fertilizer of formula 20-20-20, preferably with minor elements, should be applied once each 2 weeks, at a ratio of 1 kg in 100 l of water. To the soil itself, about 3 g of fertilizer of the formula 14-4-10 should be applied. The initial fertilizers should be high in nitrogen in order to stimulate the rapid initial growth of the trees. Once trans-

planted to a permanent field location, the trees should be fertilized twice a year with the same fertilizer applied to the soil in containers, but at a rate of about 100 g per tree. During the next 4 to 5 years, the trees should grow rapidly and vigorously. Each 6 months application should be as shown below.

Age of tree (yr)	*Fertilizer (kg)*
1	0.25
2	.5
3	1.0
4	1.25

The fertilizer is applied by scattering it under the tree, but not within 15 cm of the trunk. The appropriate time is during the spring or just before the beginning of the rainy season. In Puerto Rico, this time occurs near the end of March or the beginning of April, when the mamey sapote begins to develop new tissues. The second application should be near the end of September or in October, when the trees are entering a period of inactivity.

When the trees reach the fruit-bearing stage, naturally the interest of any farmer is to get the best possible crop. The quantity of nitrogen needed by a tree at this stage is somewhat less, for large quantities of nitrogen stimulate vigorous vegetative growth but not fruit production. At this stage, the formula for the fertilizer should be changed to 10-10-8 or 10-10-9.

The amount of fertilizer to apply to a mature tree in production depends on the development of the tree. From the fifth year on, an additional 0.5 kg of fertilizer can be applied each year for each year of age.

In some lateritic, acidic soils of Puerto Rico, deficiencies in minor nutrients, including iron and zinc, have been noted. Various foliar sprays are available commercially to correct such deficiencies.

Irrigation

Water makes up 60 percent of the weight of the leaves and stems of a plant, 75 percent of the weight of the roots, and 85 percent of the fruit. It is the medium in which the nutrients of the plant are taken up. When not available by means of rain, water should be supplied by irrigation.

As soon as the young mamey sapote tree is planted, it should be irrigated immediately. Irrigation should continue every 2 days until the plant is well established. This stage will be noted in the initiation of new buds.

The mamey sapote is highly susceptible to relatively short periods of drought. The reaction to drought is frequently a complete loss of leaves. Since the leaves are large, transpiration per leaf is high, and the plant loses moisture rapidly, making the mamey sapote especially sensitive to a lack of water.

Several irrigation techniques are suitable for the mamey sapote. Irrigation by ditches is useful in level areas where a water source is available. Aerial irrigation is more costly but more versatile. It requires specialized equipment such as pumps, tubes, and spray heads, as well as abundant water.

A new technique just introduced to Puerto Rico is the method of irrigation by drip. This practice does not require as great an amount of water as the other methods, and its installation is permanent. It is well adapted to fruit trees and is as efficient on slopes as on level ground.

In the absence of such systems, it is necessary to deliver the water in tanks and distribute it with hoses or buckets.

A good mulch will help conserve moisture, reducing the need for irrigation.

Pruning

The mamey sapote requires little pruning. Pruning should be done only when it is necessary to meet a specific goal, such as control and maintenance of the form of the tree. During the first few years pruning should be aimed at producing a well-formed tree capable of sustaining good crops of fruit. The trunk should be straight and strong with well-spaced principle branches. Branches that crowd each other or that are too near the soil should be eliminated.

When a tree is beginning to mature, it needs maintenance pruning. Dry or sick branches, or those that interfere with the harvest, should be removed. The foliage should not be so thick that light cannot penetrate or air circulate freely, for this condition reduces the resistance of the tree to diseases. The fruit develops along the length of the branches, and so a severe pruning may reduce production.

The mamey sapote grown from a seed tends to grow high, in which case it is necessary to prune the top to retain the tree at a workable height. Low trees facilitate the harvest. Grafted trees, on the other hand, tend to be short but dense.

These trees need to be opened by removing some of the lateral branches. A well-pruned tree should have well-separated principal branches and an interior free of suckers and dried or dead branches.

Some farmers prune at any season of the year, but such a habit is likely to reduce the crop. The best time to prune is when the tree is not actively growing and when it has no fruits. In Puerto Rico, this period is the dry season.

In order to remove heavy branches, first cut with the saw from the underside to about the middle of the branch. This cut should be about 15 cm from the principal trunk. A second cut is made from above about 25 cm from the trunk. When the branch falls, it will not tear and leave a jagged scar. A third cut should then be made as close to the main trunk as possible to remove the stub. The exposed surface should be treated with some type of paint, preferably one made for the purpose, to protect it from insect and fungal attacks.

Care

Often the farmer gives little attention to the operation of tillage of the orchard. It is more appropriate to think that all of the operations in the production of any crop are important. Abandonment of any one will reduce the harvest. After having established an orchard, the farmer should not then abandon the trees to luck. The principal objective of tillage is to improve the plant-soil relationship.

Tillage first includes the eradication of weeds. It is important to kill weeds before they grow sufficiently to produce seed and before they are large enough to compete with the trees themselves. Small trees are extremely susceptible to competition from weeds and suffer from lack of proper care. Unless plantations are seeded with cover crops, the ground should be maintained free of weeds in a circle 3 m in diameter around the tree.

The tillage and cleanup can be done with a disk plow, but it should be done with a cultivator that penetrates shallowly, so that the roots of the tree are not affected. The crown around the tree should be cleaned with a small mechanical weeder or even with a machete.

Tillage also loosens the soil and improves aeration, which is necessary to the roots as well as to the leaves.

The use of mulches is an old practice in many parts of the Tropics. The operation consists in providing a bed of plant refuse, straw, bagasse, or similar material around the trunk of the tree and in the area directly under the tree (fig. 9). The thickness of the mulch can be between 7.5 and 15 cm and should be renewed each year. The plant material obtained from weeding can be used for this purpose.

Mulch controls the weeds below the tree, improves the physical condition of the soil, conserves water, prevents overheating of the soil, and reduces the erosion of the soil and the washing away of fertilizer. When the tree is fruiting, a mulch reduces the damage that occurs when fruit drops from the tree.

The area between trees can be planted with another crop, not only to help with the conservation of the soil but also to provide another benefit when trees are small: such a crop can be used as a windbreak. The trees generally receive a side benefit from the fertilizer provided to such crops. The intercalated planting should not shade the small trees nor damage the roots of the trees when it is transplanted. Bananas, plantains, and pigeonpeas are excellent crops for intercalation.

When no other crops are sown, a green manure crop may be desirable. Such a crop has the advantage of rapid growth, reducing to a great extent weeding and cleanup. Normally, green manure crops are legumes because of the action

FIGURE 9.—Mulch prepared from weeds and grass to control weeds and reduce water loss.

of the associated nitrogen-fixing bacteria. When the cover crop is plowed into the soil, this nitrogen becomes available to the tree. The organic material added to the soil is also helpful.

Several species of plants are recommended as green manure or cover crops. The pigeonpea, *Cajanus indicus* L. (Druce), is one of the legumes most used in Puerto Rico. It is an important food of the Puerto Rican diet, especially near the Christmas season. Planted in the late dry season, in March or April, the pigeonpea is harvested in December. Its stems and roots are woody and slow to disintegrate, but the leaves make a good green manure. The roots penetrate deeply, and so the nitrogen-fixing nodes are widely distributed.

Crotalaria, a name applied to various species of the genus *Crotalaria*, such as *C. juncea* L. and *C. usaramoensis* R. Baker, are plants that develop an abundance of foliage in a short time. They are easy plants to grow, even in sandy soils.

The velvetbean, *Stizolobium deeringianum* Bort., a variety with the pod free of pubescence, makes an excellent cover crop. When planted during a time of moderate rains, it is vigorous, and the vines cover the ground within only a few weeks. A thick cover of 0.5 meter or more is formed if conditions are favorable. The roots are long and numerous, extending their nitrogen-forming capacity throughout the soil.

The cowpea, *Vigna unguiculata* (L.) Walp, has been widely used as a cover crop. It is an important species because it serves not only to protect the soil but also as a source of edible seed, and thus as a cash crop. It is resistant to both heat and drought, and its roots penetrate the soil deeply.

Several species of *Canavalia*, the jackbean, such as *C. ensiformis* (L.) DC and *C. gladiata* L., cover the ground well and also add nitrogen. Other species of legumes could be mentioned.

DISEASES AND INSECTS

In all crops, the best conditions for growth, such as good preparation of the soil, careful planting, adequate fertilization, and good cultivation, are of great importance in the prevention of disease and insect attacks. Fortunately, few diseases and insects attack the mamey sapote, and the amount of damage caused is seldom significant. Although in some cases the control of light attacks may hardly be worth the effort, the plantation should be watched carefully so that an unexpected spread of these conditions can be combatted.

FIGURE 10.—Damage to the leaves of a young mamey sapote caused by the sugarcane root borer, *Diaprepes abbreviatus* L.

Among the insects that attack the mamey sapote, the West Indian sugarcane root borer, *Diaprepes abbreviatus* L., should be mentioned. This insect is abundant in Puerto Rico, where it is commonly called "vaquita." The adult feeds on the leaves of a wide variety of plants such as sugarcane, citrus, coffee, avodaco, guava, and others. The adult measures 1.3 to 1.9 cm in length and is characterized by a head in the form of a beak. Its body is covered with scales arranged in strips of distinct colors. The females deposit their eggs between leaves so that they stick to each other. The larvae, white and creamy yellow in color, have an incubation period of about 7 days. They then fall to the soil where they burrow, searching for food. During their long life, the larvae remain in the soil, attacking the roots of practically all plants. When the attack is severe, it causes wilting and even death of the plant (fig. 10).

The larvae of the insect can be combatted using malathion (diethyl mercaptosuccinate *S*-ester with *0,0*-dimethyl phosphorodithioate)[3] at the rate of

[3]Regarding the use of pesticides on the mamey sapote, see "Notice to Readers" on page ii.

1 l per 378 l water applied directly to the soil around the base of the tree.

Another important pest of the mamey sapote are scales, which live in intimate contact with the plant and suck its fluids. The beak is inserted into the leaves or young stems, making a wound and a chlorotic spot that identifies its presence.

Various types of scales have been found attacking the mamey sapote. The most common type is *Pseudalacaspis pentagona* Targioni, which is round, white, with an orange center, occasionally found in quantity on the leaves and branches *(22)*.

It does not appear that the damage done by scales is enough to recommend control practices. If needed, however, scales can be combatted with an oil emulsion. Such oils are marketed commercially under a variety of names.

Another common pest of the mamey sapote is the red spider mite, *Tetranychus bimaculatus* Harvey. The leaves infested with this pest are easily recognized first by their reddish color between the veins and later by a roughened texture. The adult measures only 0.3 mm, is red, and has pubescent legs. If it becomes necessary to treat them, dusting with sulfur is recommended.

A termite, *Nasutitermes costalis* Holmgren, an insect well spread over in the island of Puerto Rico, attacks almost all trees. It begins by devouring the dead branches but later enters the living tissue. Its presence can be noted by the tunnels constructed on the outside of the bark. It is easy to combat the termite by dusting the tunnels or by placing within the nest either paris green (copper acetoarsenite) or lead arsenate.

In general, the mamey sapote has been a healthy species and has not had, at least until now, a large number of diseases. A disease that causes some damage in rainy regions is anthracnose, caused by the fungus *Colletotrichum gloeosporioides* Penz. During the rainy season in dense or shaded portions of the tree the disease progresses rapidly. It has been seen on mamey sapote near the town of Las Marías in the coffee zone of Puerto Rico, but not in other regions that are somewhat drier but still suitable for this species.

The disease results in sooty spots on the leaves and stems, and, where associated with the pedicel of the fruit, premature abscission almost always results. In contrast to other fruits, the mature fruit of the mamey sapote has never been seen to be damaged by the disease. A rare case of a severe infection can be treated with captan [*N*-[(trichloromethyl) thio]-4-cyclohexene-1,2-dicarboximide] at the rate of 1 kg/400 l of water. To prolong the effect of this treatment, a sticker-spreader is recommended.

Another disease that has caused minor damage to the mamey sapote is the fungus *Phyllosticta sapotae* Sacc., characterized by the production of pale spots in the leaves, which turn gray in the center. In these regions, small black spots of fungi can be observed. On the stems the spots are elongated, with reddish borders. This disease has been seen in the Bahamas, in Cuba, and rarely in Puerto Rico *(6)*. Treatment, if necessary, can be given by sprays of almost any fungicide, such as zineb [zinc ethylenebis (dithiocarbamate)] or ziram (zinc dimethyldithiocarbamate).

The fungus *Uredo sapotae* Sacc. is responsible for a rust that appears as brownish pustules on the underside of the leaves. At times these cause a curling and a drying up of the leaves. So far, the disease has not had an economically adverse effect on the mamey sapote.

HARVEST

The harvest of any fruit is the logical conclusion of all the efforts of the farmer to protect and care for his orchard. The harvest should be done carefully so that the product taken to the market and to the table is of the highest quality. An effort should be made to avoid blows or scratches that are common during harvest and always associated with negligence. In addition to their effects on the appearance of the fruit, harvest damages result in irregular ripening and poor storage life.

The mamey sapote begins to bear at about 7 years of age when grown from seed. Grafted trees may bear in as little as 3 years. The harvest in Puerto Rico begins in September and continues to the end of October or the beginning of November. For commercial purposes, the fruit should be harvested when it begins to redden, but for home use it is better to permit the fruit to become completely reddish before harvest.

Because the trees are large, the harvest is difficult, and the following techniques are therefore recommended. Use ladders to reach the fruit, and twist the fruit until it breaks from its stem. If impossible, use a bamboo or other pole with a cutting knife and a basket to catch the fruit. Do not let the fruit fall, for it will almost certainly

be scratched and bruised. Cut away the stem carefully, and deposit the fruit carefully in baskets or boxes. Transport the fruit in rigid containers. If the fruit is at the proper stage, it will ripen to perfection within a few days.

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